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THE DEVELOPMENT OF THE UROSTYLE IN *UMBRA PYGMAEA* (DE KAY)

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In a study of the life history and habits of the mud-minnow, *Umbra pygmaea* (De Kay), the manner of development of the urostyle was found to be of more than passing interest.[2] So different is it from fishes to which *Umbra* otherwise shows affinities, that it can only be compared with the ganoid *Lepisosteus* in this respect. Ryder, 1886, also noticed this but apparently had scanty material or did not recognize the extent of the development in *Umbra*. His remarks will be discussed at another point.

Among the teleosts that in the adult stage show an externally homocercal tail,[3] there is a rather regular extent and sequence of development of the caudal extremity. This development may be characterized as follows. First, the embryonic protocercal condition of the caudal extremity is replaced by a more or less marked upward deflection of the tip of the chorda. Coincident with this, or more generally a little later, the hypochordal fin-rays, destined to remain as the permanent tail-fin, begin to appear. With their full development, or more frequently before, the urostyle relatively retracts so that by the time the permanent rays have reached their full development, or before, there is no longer any trace of external heterocercy. That is to say, that at this stage the tail is as fully homocercal externally as in the adult.

The preceding outline of developmental sequence and extent of development, however, is not followed by *Umbra*. A brief description of the salient features in the development of this exceptional urostyle follows. The egg and very early larval development is typical of the group with which *Umbra* is associated and may be considered quite normal up to the time that the chorda begins to deflect upward. These early stages are illustrated in figure 1. As the dorsal deflection sets in, the prolongation of that part destined to be urostyle is extreme. Simultaneous with this inclination from the vertebral axis and elongation is the develop-

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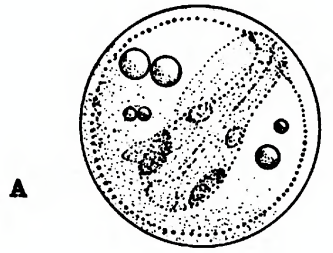
[2]The material on which this study is based was gathered at various localities within a radius of twenty-five miles of New York City and is deposited in The American Museum of Natural History.

[3]These include all those but the ganoids of the older classification; that is, the sturgeons, paddlefishes, garpikes and bowfins, all of which show external heterocercy.



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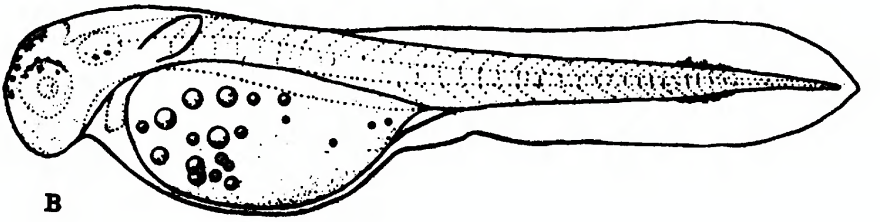

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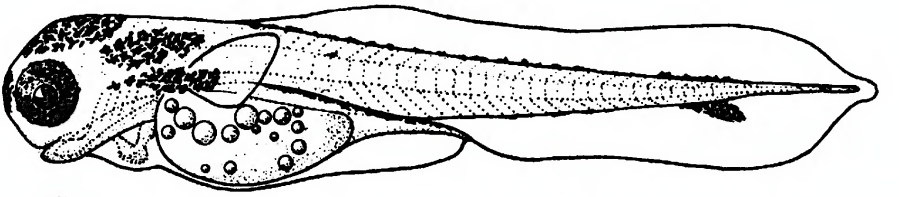

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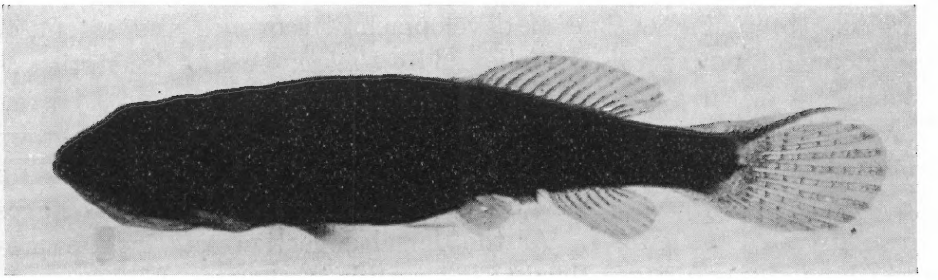

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Fig. 1. Early development of *Umbra pygmaea*. A, egg a day before hatching, 1.6 mm. diam.; B, newly hatched larva, 5.4 mm. total length; C, larva three days old, 6.0 mm. total length; D, post-larva, 14.5 mm. total length.

ment of the hypoaxial permanent fin-rays. The outline of the larval fin-fold follows the contour of these developing structures much more closely than is usual in other fishes. As development proceeds there is no relative recession into the interior of the body on the part of the urostyle, but it goes on developing, approximately equally with the rest of the fish. After the permanent fin-rays have reached their full development, the urostyle still exists as an external structure, above the tail-fin proper, free from it, and margined by its own membrane. This development, approximately, reaches its maximum when the fish is a little over 1.5 cm. in total length. After this size is passed the external urostyle begins to shrink so that at a total length of about 3.0 cm. it is entirely interior and the homocercy of the tail is externally complete. This manner of development is illustrated by the series comprising figure 2. At the time the external urostyle is most fully developed the young *Umbra* has already acquired its full adult appearance including coloration, form, and behavior. At this time the resemblance is so close as to make it entirely recognizable on sight.

Neither *Esox masquinongy* Mitchill, nor *Esox niger* LeSueur, nor any one of the numerous poeciliids and cyprinodonts well known to the writer, shows any such structure in its development. On the other hand *Lepisosteus osseus* (Linnaeus) does show a development bearing a rather close resemblance to the present. In *Lepisosteus* the external portion of the notochord is still larger and never "shrinks" to within the peduncle but remains as a permanent but adnate margin to the upper caudal fin-ray. See Agassiz, 1879, and Fish, 1932, for figures of development, and Kolliker, 1859, for a dissection of the adult tail.

The relatively slight flattening of the hypurals in the adult (Fig. 2F) presents a condition rather similar to that shown by *Esox*, as would be expected on a basis of the general similarity of these two genera.

A somewhat similar case is reported by Meinken, 1927, who describes and figures what he considers to be an adipose fin in the young stages of *Nannostomus anomalus* Steindachner. This structure, Myers, 1928, actually appears to be a remarkably developed urostyle. Although this characin is neither related nor especially resembles *Umbra* it is odd that both habitually strike a similar peculiar pose when resting; that is, they usually rest with the body axis slanted from the horizontal with the head up in a strikingly characteristic manner.

Ryder, 1886, wrote of *Umbra:* "Immediately after hatching it is observed that there is a small projecting lobe at the end of the tail. Into this lobe the notochord extends. This terminal lobe of the tail is

much narrower than the portion of the caudal lobe just in advance of it. As development proceeds it also becomes longer and more conspicuous. This terminal lobe of the tail of the larval mud-minnow is clearly homologous with the *opisthure* of the larval *Lepidosteus* and the adult *Chimaera monstrosa*. It is certain that it is subsequently absorbed, since the more advanced stages prove that the rays of the permanent caudal fin are developed far in advance of the opisthural lobe above described.

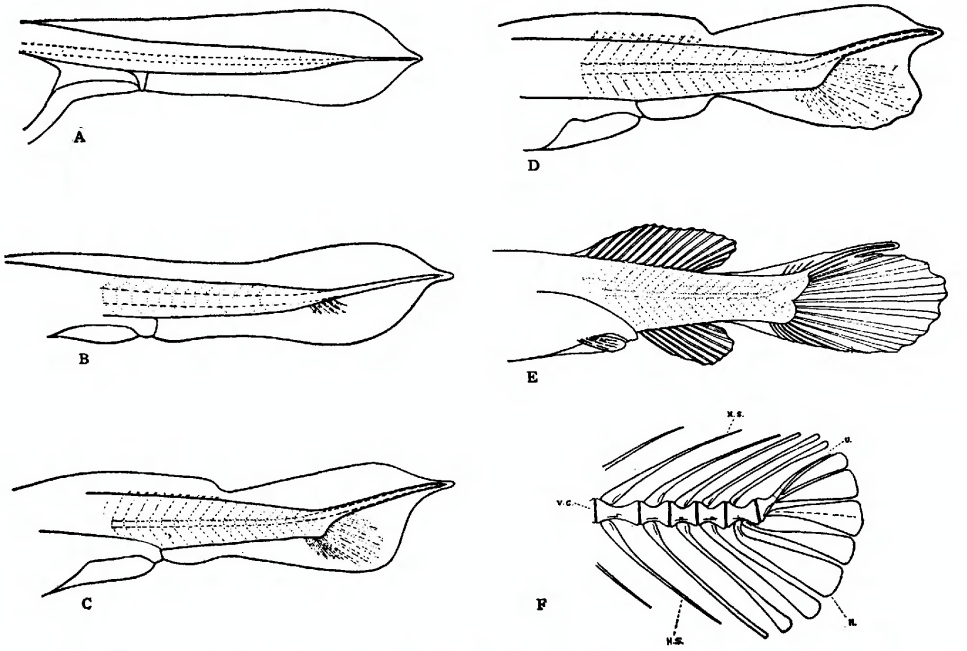

Fig. 2. Development of the tail of *Umbra pygmaea*. Camera-lucida drawings. Measurements represent total length of the fish.

A, 4.75 mm.; B, 6.5 mm.; C, 8.5 mm.; D, 10.0 mm.; E, 15.0 mm.
F, 45.5 mm., adult, skeletal parts with fin rays removed: *H*, hypurals; *H*, *S*, haemal spines; *N. S.*, neural spines; *U*, urostyle; *V. C.*, vertebral column.

"There is a slight tendency to form an opisthural lobe in the larva of the pike, but the larva of none of the teleostean forms hitherto studied approach the Rhomboganoids so closely in respect to the manner in which the tail is developed as *Umbra*."

The "slight tendency to form such a lobe" on the part of *Esox* is certainly no greater than that of numerous other fishes but differs distinctly from *Umbra*, as already pointed out, especially in regard to the relative rates and times of development of the urostyle fin-rays. Nor is it clear that this structure "is homologous with the opisthure of larval *Lepisosteus*."

Whether this development can be considered as a retention of a primitive character, or a new specialization of possibly some functional significance, can only be determined by further study probably including histological examination and experimental procedure.

The resemblance of *Umbra* to *Amia* has been noted by Hildebrand, 1923, but is certainly nothing more than the incidental convergence of unlike forms occupying similar environmental places. This similarity of habitus prompted a comparison with the figures of *Amia* given by Dean, 1896. These at once show that this ganoid develops no such exaggerated urostyle as is present in either *Umbra* or *Lepisosteus*. Although there is a slight permanent external heterocercy the urostyle of *Amia* is small and ceases to be a protruding element before the permanent caudal rays fully develop and, so far as this feature goes, follows the generalized development of teleosts much more closely than does *Umbra*.

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